

General Disclaimer

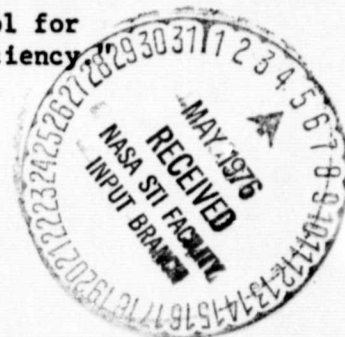
One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.
- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.
- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.
- This document is paginated as submitted by the original source.
- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

Grant Number: NAS 9-14134-1S "Program to Study Optimal Protocol for Cardiovascular and Muscular Efficiency"

Sponsoring Institution: Harding College, Searcy, Arkansas

Period Covered by the Report: July 1, 1975 - December 31, 1975



This report covers Experiment IV of four experiments to be conducted during a 24-month period beginning January 1, 1974. In Experiment I three groups of males trained twenty minutes a day, three days a week for ten weeks. One group trained on the Super Mini-Gym, a second group trained on the Universal Gym, and a third performed calisthenics. Cardiopulmonary gains were negligible but all training groups exhibited good gains in strength.

In Experiment II three groups of males trained twenty minutes a day, three days a week for ten weeks. One group trained on a floor model Super Mini-Gym, a second group trained on a Super Mini-Gym bicycle at low resistance, and a third group trained on a Super Mini-Gym bicycle at high resistance. The floor model produced a moderate increase in strength and a very slight increase in cardiopulmonary fitness. The bicycle produced negligible gains in strength and a very slight increase in cardiopulmonary fitness. The bicycle was found to have mechanical faults which make it unsuitable as a piece of exercise equipment.

In Experiment III three groups of males trained twenty minutes a day, three days a week for ten weeks on a Monarch stationary bicycle. One group trained in an upright position at a pulse rate of 160 beats per minute, a second group trained in a supine position at the same pulse rate and a third trained in a supine position at an intensity equal to the group training in an upright posture. Negligible increases in strength were produced. All training groups made moderate increases in cardiopulmonary fitness.

In Experiment IV three groups of females trained twenty minutes a day, three days a week for ten weeks at a pulse rate of 85 percent of the maximum attained during a treadmill test. One group trained on a Monarch stationary bicycle, a second group trained by running on an outdoor track, and a third group trained by walking on a treadmill. All training groups had some gains in strength and physical work capacity. The running group had lesser gains in both areas.

The authors express appreciation to Dr. Jim Meade, Dr. Robert Walls, Ms. Carolyn Thompson, and Mr. William C. Hunter of the Biometry Division, University of Arkansas Medical School, for their assistance in the analysis of the data.

Experiment IV: Comparison of Bicycling, Running, and Treadmill
Walking for Developing Physical Work Capacity

Harry Olree, Bob Corbin, David Elliott, Carroll Smith
Harding College, Searcy, Arkansas

I. Introduction

A number of physiological changes, which are in general referred to as deconditioning, result from living in the environment of space. Two possible ways to minimize the effects of deconditioning in space are to achieve a very high level of conditioning immediately prior to flight and provide a regimen in the capsule which will conserve pre-flight physical fitness and maintain a moderate degree of fitness. This laboratory has been investigating methods and equipment to determine how these two goals might be efficiently attained.

It was determined in this laboratory that running and riding a bicycle ergometer at comparable heart rates produced similar gains in physical fitness variables. It was found that subjects who exercised at a 180 heart rate made greater gains in physical fitness than did those exercising at a 140 or 160 heart rate. When the length of the workout was varied, subjects exercising sixty minutes per day made greater gains than those exercising twenty or forty minutes per day. Greater gains on specified components of physical fitness also resulted when subjects exercised twelve times per week as compared to those who exercised three or six times a week. Subjects who discontinued training slowly deconditioned, but a moderate level of fitness could be maintained by exercising at a pulse rate of 160 beats per minute for twenty-minute periods three times a week. Subjects who "overtrained" twice daily to near exhaustion increased in fitness.

Exercise programs involving four pieces of equipment, the Exer-Genie Exerciser, the Collins Pedal Mode Ergometer, the Universal Gym and the Super Mini-Gym, have been investigated. It was found that neither six- nor twelve-minute training periods each day involving isometric and isotonic exercises with an Exer-Genie resulted in significant increases in selected physical fitness variables. Training in a supine position on the Exer-Genie at a 160 pulse rate for twenty minutes per day showed no significant change in fitness. Three training programs involving the Collins Ergometer have been examined. One group of subjects exercised for twelve minutes per day with the heart rate programmed to increase during the training period. Another group exercised for ten minutes a day 85 percent of their maximum heart rate while a third group exercised at a 160 heart rate for ten minutes a day. Each of these groups showed moderate increases in fitness.

Moderate gains in physical fitness were produced in three exercise groups of men 30-45 years old who were initially in poor to fair condition. One group exercised for ten minutes a day, three times a week on a bicycle ergometer at 85 percent maximum pulse rate. Another group exercised for ten minutes a day, five times a week on a bicycle ergometer at 85 percent maximum pulse rate. The third group exercised for ten minutes a day, three times a week on the bicycle ergometer at 85 percent maximum pulse rate and two times a week on an Exer-Genie circuit. These three exercise groups made comparable gains in fitness.

A combination of exercises has been investigated. One group of subjects exercised for twenty minutes a day, three days a week, on a foot-mode ergometer at 85 percent maximum pulse rate and twenty minutes a day, two days a week, on a hand-mode ergometer at 70 percent maximum pulse rate. A second group had the same schedule but worked on the hand-mode ergometer at 85 percent

maximum pulse rate. The third group exercised for twenty minutes a day, three days a week, on a foot-mode ergometer at 85 percent maximum pulse rate and two days a week on a seven-station Exer-Genie circuit. These groups made moderate gains in strength and cardiopulmonary fitness.

Another combination included endurance and strength training in the same workout. The three exercise groups worked fifteen minutes a day, three days a week on a foot-mode ergometer at 85 percent of their maximum heart rate. Each group immediately followed this with an additional fifteen minutes of exercise. One group completed two circuits on a seven-station Exer-Genie circuit at each exercise session. One group exercised on a hand-mode ergometer. The third group completed two circuits on a seven-station Super Mini-Gym circuit during each exercise session. All groups made moderate cardiopulmonary gains but only the Exer-Genie and the Mini-Gym were effective in increasing strength.

An experiment was performed to compare exercise on equipment designed solely to produce strength, exercise of the lower torso only to produce cardiopulmonary fitness and exercise of the upper torso only so as to produce cardiopulmonary fitness. One group worked thirty minutes a day, three days a week, on a Universal Gym. Another group worked thirty minutes a day, three days a week, on a foot-mode ergometer at 85 percent of their maximum pulse rate. A third group worked thirty minutes a day, three days a week, on a hand-mode ergometer at 85 percent of their maximum pulse rate. The group exercising on the Universal Gym gained in arm and shoulder girdle strength. The subjects exercising on the foot-mode ergometer gained in leg strength and all groups made moderate gains in cardiorespiratory fitness.

The effect of stress on highly trained subjects has been investigated by confining one group in bed for five days and depriving a second group

of sleep for fifty hours. The pre-stress training, which lasted twelve weeks, consisted of a three-mile run three days a week and working on a Universal Gym for thirty minutes a day, twice a week. Good increases in strength and cardiopulmonary fitness were obtained. Both stresses caused negligible decreases in strength variables but drastic decreases in cardiopulmonary fitness. Two weeks post-stress the subjects had recovered about half of the conditioning they lost.

In an experiment comparing the Super Mini-Gym, the Universal Gym and calisthenics, subjects trained twenty minutes a day three days a week. The training programs produced comparable results, negligible increases in cardiopulmonary fitness and good gains in strength.

The Super Mini-Gym bicycle was evaluated and compared with the floor model. The bicycle was found to have serious mechanical faults. One group on the bicycle trained at high resistance while the second group on the bicycle trained at a low resistance. Pedal speed was adjusted so that pulse rates were comparable. Slight gains in strength and cardiopulmonary fitness resulted. However, the floor model produced good gains in strength.

The effects of bodily posture were investigated by training one group in an upright position at a pulse rate of 160 beats per minute, a second group in a supine position at the same pulse rate and a third trained in a supine position at a work intensity equal to the group training in an upright posture. All training groups made moderate increases in cardiopulmonary fitness and slight increases in strength.

II. Purpose

The purpose of this experiment was to determine the relative effectiveness of bicycling, running and treadmill walking for increasing physical work capacity in college-age females.

III. Methods

The subjects in this experiment were twenty college-age female volunteers whose physical work capacity was average for the Harding College coed. Base lines were determined on specified variables by administering the following: (a) a medical examination, (b) anthropometrical measurements, (c) skinfold measurements, (d) body composition measurements, (e) three cable tensiometer strength measurements, (f) three Cybex dynamometer strength measurements, and (g) a treadmill test.

The medical examination included a six-lead ECG, a vital capacity test (1), a maximum breathing capacity test (1), and serum and urine analyses for glucose. The following anthropometrical measurements were taken: neck, bicep, forearm, waist, thigh and calf. The following skinfold measurements (2) were taken: axilla, tricep, subscapular, abdominal, suprailiac, and thigh. A sum of the values for these six sites was calculated. Body composition measurements (3) were determined by hydrostatic weighing with the subject sitting. Cable tensiometer measurements (4) of shoulder flexion, hip flexion and ankle plantar flexion were taken. Using a Cybex dynamometer, measurements of both flexion and extension of the elbow, knee and hip were taken (5).

Each subject was given a treadmill test (6) in which the speed of the belt was constant at 90 meters per minute with an increment in grade of one percent per minute. Pulse rate and blood pressure (systolic and diastolic) were measured manually on alternate minutes until a pulse rate of 160 beats per minute was attained. Thereafter, the pulse and pressure were monitored each minute. The test was terminated when the subject reached a near maximum pulse rate. Expired gas samples were collected at a 180 pulse rate and the last minute to determine several measurements of cardiorespiratory fitness. Pulse and pressure were monitored post-test for three minutes with the subject sitting.

By using a table of random numbers the twenty subjects were divided into four groups of five each. Subjects in Groups A, B, and C trained and Group D served as a control, engaging in their normal daily activities without any specified training program.

The training lasted ten weeks and during this time the groups exercised for twenty-minute periods three times per week. All groups trained at 85 percent of the maximum pulse rate attained during the treadmill test. Pulse rates were monitored manually every two to five minutes during workouts. Group A trained on a Monarch stationary bicycle. Group B trained by jogging on a quarter-mile track. Group C walked on a treadmill at 3.5 miles per hour with the elevation varied so as to produce the required heart rate.

The effects of the training program were evaluated at the end of the experiment by readministering the initial baseline tests.

The data were analyzed by analysis of variance and Duncan's Multiple Range tests on selected contrasts where indicated. The following model was used for the analysis of variance: $Y_{ijkl} = U + A_i + B_{j(i)} + C_k + E_{l(ijk)}$, where A represents the groups and is considered fixed, B represents the subjects and is considered random, and C represents the tests and is considered fixed.

In the Anova Table the number of observations (N) is forty for all variables. The number of groups (n) is four, the number of subjects per group (p) is five and the number of tests (q) is two for all variables.

TABLE I
ANOVA TABLE

Source	Df	E(ms)	F
Total	N-1		
(A) Groups	n-1	(1) $\sigma_E^2 + q \sigma_{B(A)}^2 + pq \sigma_A^2$	1/2
B(A) Subjects in Groups	n(p-1)	(2) $\sigma_E^2 + q \sigma_{B(A)}^2$	
C Tests	(q-1)	(3) $\sigma_E^2 + \sigma_{[B(A)C]}^2 + np \sigma_C^2$	3/5
AC Groups, Tests Interaction	(n-1)(q-1)	(4) $\sigma_E^2 + \sigma_{[B(A)]C}^2 + p \sigma_{AC}^2$	4/5
[B(A)]C Subjects in Groups, Tests Interaction	n(p-1)(q-1)	(5) $\sigma_E^2 + \sigma_{[B(A)]C}^2$	

IV. Results and Discussion

The average age, height, and weight for each group prior to the beginning of the training are given in Table II.

TABLE II
MEAN AGE, HEIGHT, AND WEIGHT OF SUBJECTS

GROUP	AGE (yr)	HEIGHT (cm)	WEIGHT (kg)
A - Bicycle	20.8	170.6	62.7
B - Running	21.2	169.4	63.1
C - Treadmill	20.8	168.6	66.5
D - Control	21.0	166.4	61.3
ALL	20.9	168.8	63.4

The significant changes that were found for all variables that were measured pre- and post-training are listed in Table III. The significance level is indicated ($p < 0.1$, 0.05, 0.01 or 0.001). A significant decrease is indicated by a minus sign in front of the significance level and a significant increase is indicated by the lack of a sign.

Table IV contains the mean pre- and post-training values of all the variables that were measured.

Groups A and B had significant increases in girth measurements for both thighs and both calves, whereas, Group C, walking on the treadmill did not show any change (Table III).

TABLE III
SIGNIFICANCE LEVELS OF CHANGES IN VARIABLES MEASURED
PRE- AND POST-TRAINING

VARIABLE	GROUP			
	A Bicycle	B Running	C Treadmill	D Control
<u>ANTHROPOMETRIC MEASUREMENTS</u>				
Neck				
Right Bicep				
Left Bicep				
Right Forearm				
Left Forearm				.05
Waist	.05			
Right Thigh	.1	.01		
Left Thigh	.01	.05		
Right Calf	.05	.05		
Left Calf	.05	.01		
<u>SKINFOLD MEASUREMENTS</u>				
Axilla			.1	
Tricep				
Subscapular				
Abdominal				
Suprailiac				
Thigh	.1			
Sum of Sites				
<u>STRENGTH MEASUREMENTS</u>				
Shoulder Flexion, Cable	.05	.05	.05	
Hip Flexion, Cable		.05		
Ankle Plantar Flexion, Cable	.05		.1	

TABLE III...SIGNIFICANCE LEVELS OF CHANGES IN VARIABLES MEASURED PRE- AND POST-
TRAINING CONTINUED

VARIABLE	GROUP			
	A Bicycle	B Running	C Treadmill	D Control
<u>Strength Measurements Continued</u>				
Strength Quotient	.05		.05	
T Score	.05		.1	
Elbow Flexion, Cybex				
Elbow Extension, Cybex				
Knee Flexion, Cybex		.05		.1
Knee Extension, Cybex	.05			
Hip Flexion, Cybex			-.05	
Hip Extension, Cybex	.05			
<u>PHYSIOLOGICAL VARIABLES</u>				
One Second Vital Capacity			-.05	
Maximum Vital Capacity				
Maximum Breathing Capacity				.01
Respiratory Rate at MBC				
Tidal Volume at MBC				.05
Body Composition				
Weight			-.001	-.01
<u>TREADMILL TEST VARIABLES</u>				
Time on Treadmill to 180 P.R.	.001	.01	.001	
Time on Treadmill to Max. P.R.	.001	.001	.001	
Systolic Blood Pressure at Rest			-.05	
Systolic Blood Pressure at 180 P.R.				
Systolic Blood Pressure at Max. P.R.				
Systolic Blood Pressure at 3rd Minute Recovery				-.1

TABLE III...SIGNIFICANCE LEVELS OF CHANGES IN VARIABLES MEASURED PRE- AND POST-
TRAINING CONTINUED

VARIABLE	GROUP			
	A Bicycle	B Running	C Treadmill	D Control
Diastolic Blood Pressure at Rest				
Diastolic Blood Pressure at 180 P.R.			-.01	
Diastolic Blood Pressure at Max. P.R.			-.05	
Diastolic Blood Pressure at 3rd Minute Recovery				
Pulse Rate at Rest				
Pulse Rate at 180 P.R.				
Pulse Rate at Max. P.R.	-.05	-.1	-.05	
Pulse Rate at 3rd Minute Recovery	-.05	-.05	-.05	
\dot{V}_E BTPS at 180 P.R.	.05			
\dot{V}_E BTPS at Max. P.R.	.05	-.05		-.1
\dot{V}_E STPD at 180 P.R.	.05			
\dot{V}_E STPD at Max. P.R.	.05	-.05		-.1
Respiratory Rate at 180 P.R.	.1			
Respiratory Rate at Max. P.R.		-.05		
Tidal Volume at 180 P.R.			.05	
Tidal Volume at Max. P.R.				
\dot{V}_{O_2} at 180 P.R.	.05		.05	
\dot{V}_{O_2} at Max. P.R.			.1	
\dot{V}_{O_2} /Pulse at 180 P.R.	.05		.01	
\dot{V}_{O_2} /Pulse at Max. P.R.			.05	
\dot{V}_{O_2} /kgbw·min at 180 P.R.	.05		.05	
\dot{V}_{O_2} /kgbw·min at Max. P.R.			.05	
\dot{V}_E/\dot{V}_{O_2} at 180 P.R.				
\dot{V}_E/\dot{V}_{O_2} at Max. P.R.	.1	-.05	-.1	

Significant changes in strength did not correlate closely with anthropometric changes (Table III). It is apparent that all training groups did increase in strength. The two derived variables, Strength Quotient and T Score, indicate overall strength increases. The T Score is a percentile of the norm. Groups A and C had significant increases in overall strength as indicated by these two variables.

There was no significant change in body composition as indicated by hydrostatic weighing and the sum of skinfold measurements taken at six sites.

The variables in Table III that are most indicative of physical work capacity are Time on the Treadmill and $\dot{V}_{O_2}/\text{kgbw}\cdot\text{min.}$ All training groups had highly significant increases in Time on Treadmill to 180 Pulse Rate and to Maximum Pulse Rate. Groups A and C had significant increases in $\dot{V}_{O_2}/\text{kgbw}\cdot\text{min.}$ to 180 Pulse Rate, whereas, only Group C had a significant increase in $\dot{V}_{O_2}/\text{kgbw}\cdot\text{min.}$ at Maximum Pulse Rate. The post-training values for $\dot{V}_{O_2}/\text{kgbw}\cdot\text{min.}$ to a 180 Pulse Rate for Groups A, B, and C represent increases of 14 percent, 4 percent, and 15 percent respectively. In a similar experiment conducted in 1967 using college age males, increases of 15 percent, 24 percent, and 7 percent were found in oxygen uptake per kilogram of body weight measured at a 180 Pulse Rate.

It is interesting that the running group, Group B, made no significant gains in $\dot{V}_{O_2}/\text{kgbw}\cdot\text{min.}$ at either 180 Pulse Rate or Maximum Pulse Rate. It is more difficult to closely monitor the pulse rate by manual methods of subjects that are running. In addition, the subject must interrupt exercise for ten seconds each time the rate is counted. It is possible that this could affect the results of the training.

V. Conclusions

1. Pedalling a stationary bicycle, running on an outdoor track and walking on a treadmill produced increases in strength variables. Pedalling a bicycle and walking a treadmill produced greater increases in overall strength.

2. Pedalling a bicycle, running, and walking on a treadmill produced good gains in physical work capacity as measured by Time on the Treadmill during the Balke treadmill test.

3. Pedalling a bicycle and walking on a treadmill produced moderate gains in cardiorespiratory fitness as measured by $\dot{V}_{O_2}/\text{kgbw}\cdot\text{min}$. In this experiment there was no significant increase in this variable for subjects who trained by running on an outdoor track.

TABLE IV
MEAN PRE- AND POST-TRAINING VALUES OF
THE MEASURED VARIABLES BY GROUPS

VARIABLE		GROUP			
		A Bicycle	B Running	C Treadmill ¹	D Control
<u>ANTHROPOMETRIC MEASUREMENTS</u>					
Neck (cm)	Pre	29.78	30.58	31.60	30.06
	Post	30.26	30.90	32.08	30.22
	Difference	.48	.32	.48	.16
Right Bicep (cm)	Pre	26.90	28.26	27.52	27.36
	Post	27.06	28.12	27.40	27.48
	Difference	.16	-.14	-.12	.12
Left Bicep (cm)	Pre	26.10	27.18	26.40	26.22
	Post	26.06	27.38	26.22	26.56
	Difference	-.04	.20	-.18	.34
Right Forearm (cm)	Pre	23.14	24.20	23.88	23.94
	Post	23.10	24.14	24.00	24.00
	Difference	-.04	-.06	.12	.06
Left Forearm (cm)	Pre	22.54	23.50	23.04	23.04
	Post	22.38	23.42	23.14	23.34
	Difference	-.16	-.08	.10	.30
Waist (cm)	Pre	65.72	69.98	71.30	64.82
	Post	67.32	70.88	71.34	65.40
	Difference	1.60	.90	.04	.58
Right Thigh (cm)	Pre	54.08	52.86	56.30	53.74
	Post	54.86	54.18	56.46	54.20
	Difference	.78	1.32	.16	.46
Left Thigh (cm)	Pre	53.62	52.34	55.66	53.52
	Post	55.18	53.70	55.76	53.98
	Difference	1.56	1.36	.10	.46
Right Calf (cm)	Pre	35.16	33.70	35.20	34.82
	Post	35.70	34.26	35.38	34.70
	Difference	.54	.56	.18	-.12

TABLE IV...MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS
...CONTINUED

VARIABLE		GROUP			
		A Bicycle	B Running	C Treadmill	D Control
<u>Anthropometric Measurements Continued</u>					
Left Calf (cm)	Pre	35.48	33.34	35.46	34.70
	Post	35.96	34.08	35.80	34.84
	Difference	.48	.74	.34	.14
<u>SKINFOLD MEASUREMENTS</u>					
Axilla (mm)	Pre	7.66	10.12	9.64	8.08
	Post	8.40	10.96	11.32	7.36
	Difference	.74	.84	1.68	-.72
Tricep (mm)	Pre	15.04	13.00	12.32	18.40
	Post	14.68	13.56	13.48	16.36
	Difference	-.36	.56	1.16	-2.04
Subscapular (mm)	Pre	10.24	12.06	12.96	10.88
	Post	10.16	12.04	13.16	10.60
	Difference	-.08	-.02	.20	-.28
Abdominal (mm)	Pre	15.72	15.84	19.28	13.76
	Post	14.16	16.08	19.36	13.36
	Difference	-1.56	.24	.08	-.40
Suprailiac (mm)	Pre	9.40	10.76	13.12	10.20
	Post	9.00	10.84	14.00	8.40
	Difference	-.40	.08	.88	-1.80
Thigh (mm)	Pre	22.90	18.88	23.08	23.44
	Post	25.52	21.04	23.62	23.36
	Difference	2.62	2.16	.54	-.08
Sum of Six (mm)	Pre	80.96	80.66	90.40	84.76
	Post	81.92	84.12	94.94	81.64
	Difference	.96	3.46	4.54	-3.12
<u>STRENGTH MEASUREMENTS</u>					
Shoulder Flexion, Cable (lb)	Pre	45.20	43.00	46.00	49.00
	Post	52.80	52.20	53.40	51.80
	Difference	7.60	9.20	7.40	2.80
Hip Flexion, Cable (lb)	Pre	84.40	75.60	83.40	92.40
	Post	92.00	97.00	94.80	90.60
	Difference	7.60	21.40	11.40	-1.80

TABLE IV...MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS
...CONTINUED

VARIABLE		GROUP			
		A Bicycle	B Running	C Treadmill	D Control
Strength Measurements <u>Continued</u>					
Ankle Plantar Flexion, Cable (lb)	Pre	255.80	263.80	259.60	280.20
	Post	308.40	271.00	301.00	286.20
	Difference	52.60	7.20	41.40	6.00
Strength Quotient	Pre	.932	.814	.876	.960
	Post	1.076	.902	1.018	.968
	Difference	.144	.088	.142	.008
T Score	Pre	52.80	53.80	54.60	59.00
	Post	61.60	58.40	61.40	59.40
	Difference	8.80	4.60	6.80	.40
Elbow Flexion, Cybex (lb)	Pre	29.20	30.80	26.60	28.20
	Post	25.60	31.80	29.40	29.20
	Difference	-3.60	1.00	2.80	1.00
Elbow Extension, Cybex (lb)	Pre	33.20	36.80	32.20	36.60
	Post	34.40	43.00	36.40	39.00
	Difference	1.20	6.20	4.20	2.40
Knee Flexion, Cybex (lb)	Pre	33.60	32.80	45.00	32.20
	Post	38.00	46.00	40.20	42.20
	Difference	4.40	13.20	-4.80	10.00
Knee Extension, Cybex (lb)	Pre	44.00	61.20	49.80	62.20
	Post	62.20	64.00	57.40	63.80
	Difference	18.20	2.80	7.60	1.60
Hip Flexion, Cybex (lb)	Pre	18.40	23.00	22.20	24.00
	Post	21.00	22.20	15.80	22.40
	Difference	2.60	-.80	-6.40	-1.60
Hip Extension, Cybex (lb)	Pre	94.40	111.60	102.20	86.40
	Post	117.40	112.80	93.80	94.40
	Difference	23.00	1.20	-8.40	8.00

TABLE IV...MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS
...CONTINUED

VARIABLE		GROUP			
		A Bicycle	B Running	C Treadmill	D Control
<u>PHYSIOLOGICAL VARIABLES</u>					
One Second Vital Capacity (l)	Pre	3.08	3.30	3.02	3.12
	Post	3.02	3.32	2.90	3.12
	Difference	-.06	.02	-.12	.00
Maximum Vital Capacity (l)	Pre	3.58	3.66	3.64	3.64
	Post	3.68	3.76	3.52	3.58
	Difference	.10	.10	-.12	-.06
Maximum Breathing Capacity (liters/min.)	Pre	132.40	157.80	136.80	131.00
	Post	135.00	163.00	136.20	142.20
	Difference	2.60	5.20	-.60	11.20
Respiratory Rate at MBC	Pre	119.40	137.40	121.80	124.80
	Post	111.60	125.60	118.20	107.40
	Difference	-7.80	-11.80	-3.60	-17.40
Tidal Volume at MBC (l)	Pre	1.16	1.16	1.14	1.08
	Post	1.20	1.32	1.18	1.30
	Difference	.04	.16	.04	.22
Body Composition (percent fat)	Pre	25.24	25.18	28.58	26.64
	Post	24.44	24.92	28.30	26.36
	Difference	-.80	-.26	-.28	-.28
Weight (kg)	Pre	62.68	63.06	66.46	61.26
	Post	62.14	63.50	64.62	59.84
	Difference	-.54	.44	-1.84	-1.42
<u>TREADMILL TEST VARIABLES</u>					
Time on Treadmill to 180 P.R. (min.)	Pre	8.40	10.40	9.80	9.20
	Post	12.20	13.00	13.20	8.80
	Difference	3.80	2.60	3.40	-.40
Time on Treadmill to Max. P.R. (min.)	Pre	13.20	14.40	13.00	12.00
	Post	15.40	16.20	17.00	12.40
	Difference	2.20	1.80	4.00	.40
Systolic Blood Pressure at Rest (mmHg)	Pre	118.00	120.00	126.00	122.00
	Post	117.00	120.00	117.00	115.00
	Difference	-1.00	.00	-9.00	-7.00

TABLE IV...MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS
...CONTINUED

VARIABLE		GROUP			
		A Bicycle	B Running	C Treadmill	D Control
Treadmill Test Variables Continued					
Systolic Blood Pressure at 180 P.R. (mmHg)	Pre	168.00	167.00	169.00	155.00
	Post	172.00	172.00	169.00	155.00
	Difference	4.00	5.00	.00	.00
Systolic Blood Pressure at Max. P.R. (mmHg)	Pre	174.00	178.00	174.00	163.00
	Post	182.00	183.00	173.00	161.00
	Difference	8.00	5.00	-1.00	-2.00
Systolic Blood Pressure at 3rd Minute Recovery (mmHg)	Pre	138.00	148.00	137.00	150.00
	Post	147.00	154.00	134.00	140.00
	Difference	9.00	6.00	-3.00	-10.00
Diastolic Blood Pressure at Rest (mmHg)	Pre	77.00	74.00	81.00	80.00
	Post	78.00	73.00	78.00	77.00
	Difference	1.00	-1.00	-3.00	-3.00
Diastolic Blood Pressure at 180 P.R. (mmHg)	Pre	72.00	69.00	76.00	73.00
	Post	68.00	72.00	65.00	73.00
	Difference	-4.00	3.00	-11.00	.00
Diastolic Blood Pressure at Max. P.R. (mmHg)	Pre	70.00	68.00	73.00	69.00
	Post	66.00	64.00	64.00	71.00
	Difference	-4.00	-4.00	-9.00	2.00
Diastolic Blood Pressure at 3rd Minute Recovery (mmHg)	Pre	80.00	75.00	81.00	79.00
	Post	80.00	77.00	81.00	80.00
	Difference	.00	2.00	.00	1.00
Pulse Rate at Rest (beats/min.)	Pre	80.80	76.00	89.60	80.00
	Post	82.40	79.20	80.00	78.40
	Difference	1.60	3.20	-9.60	-1.60
Pulse Rate at 180 P.R. (beats/min.)	Pre	180.00	180.80	182.40	181.60
	Post	180.00	180.00	180.80	180.00
	Difference	.00	-.80	-1.60	-1.60

TABLE IV...MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS
...CONTINUED

VARIABLE		GROUP			
		A Bicycle	B Running	C Treadmill	D Control
Treadmill Test Variables Continued					
Pulse Rate at Max. P.R. (beats/min.)	Pre	199.20	194.40	196.80	199.20
	Post	194.40	191.20	192.80	199.20
	Difference	-4.80	-3.20	-4.00	.00
Pulse Rate at 3rd Minute Recovery (beats/min.)	Pre	127.20	121.60	124.80	124.80
	Post	114.40	108.80	112.80	118.40
	Difference	-12.80	-12.80	-12.00	-6.40
\dot{V}_E BTPS at 180 P.R. (l)	Pre	53.60	64.20	71.40	62.00
	Post	66.00	65.40	77.20	56.40
	Difference	12.40	1.20	5.80	-5.60
\dot{V}_E BTPS at Max. P.R. (l)	Pre	77.60	89.60	94.40	81.20
	Post	87.20	79.60	93.80	74.40
	Difference	9.60	-10.00	-.60	-6.80
\dot{V}_E STPD at 180 P.R. (l)	Pre	44.80	53.20	59.20	51.60
	Post	55.40	54.40	64.20	47.20
	Difference	10.60	1.20	5.00	-4.40
\dot{V}_E STPD at Max. P.R. (l)	Pre	64.80	74.00	77.80	67.60
	Post	73.20	66.20	78.40	62.20
	Difference	8.40	-7.80	.60	-5.40
Respiratory Rate at 180 P.R. (breaths/min.)	Pre	27.40	29.80	40.20	31.20
	Post	34.00	30.40	37.00	31.20
	Difference	6.60	.60	-3.20	.00
Respiratory Rate at Max. P.R. (breaths/min.)	Pre	38.80	43.80	47.00	40.60
	Post	41.00	35.60	44.40	38.00
	Difference	2.20	-8.20	-2.60	-2.60
Tidal Volume at 180 P.R. (l)	Pre	1.96	2.16	1.84	2.02
	Post	1.94	2.16	2.14	1.88
	Difference	-.02	.00	.30	-.14

TABLE IV...MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS
...CONTINUED

VARIABLE		GROUP			
		A Bicycle	B Running	C Treadmill	D Control
<u>Treadmill Test Variables Continued</u>					
Tidal Volume at Max. P.R. (l)	Pre	2.02	2.08	2.06	2.04
	Post	2.14	2.26	2.24	2.00
	Difference	.12	.18	.18	-.04
\dot{V}_{O_2} at 180 P.R. (l)	Pre	1.740	1.866	1.900	1.694
	Post	1.998	1.928	2.186	1.630
	Difference	.258	.062	.286	-.064
\dot{V}_{O_2} at Max. P.R. (l)	Pre	2.194	2.244	2.254	2.140
	Post	2.274	2.166	2.404	2.038
	Difference	.080	-.078	.150	-.102
\dot{V}_{O_2} /Pulse at 180 P.R. (ml)	Pre	9.68	10.34	10.42	9.32
	Post	11.12	10.72	12.10	9.06
	Difference	1.44	.38	1.68	-.26
\dot{V}_{O_2} /Pulse at Max. P.R. (ml)	Pre	10.98	11.56	11.44	10.74
	Post	11.70	11.32	12.42	10.24
	Difference	.72	-.24	.98	-.50
\dot{V}_{O_2} /kgbw·min. at 180 P.R. (ml)	Pre	27.56	29.44	28.70	27.72
	Post	31.50	30.52	32.92	26.98
	Difference	3.94	1.08	4.22	-.74
\dot{V}_{O_2} /kgbw·min. at Max. P.R. (ml)	Pre	34.68	35.60	33.98	34.96
	Post	35.86	34.56	36.36	33.86
	Difference	1.18	-1.04	2.38	-1.10
\dot{V}_E/\dot{V}_{O_2} at 180 P.R. (l)	Pre	30.90	34.76	37.92	36.70
	Post	33.12	33.88	35.36	34.62
	Difference	2.22	-.88	-2.56	-2.08
\dot{V}_E/\dot{V}_{O_2} at Max. P.R. (l)	Pre	35.72	39.64	42.06	38.74
	Post	38.56	36.52	39.28	37.08
	Difference	2.84	-3.12	-2.78	-1.66

References

1. Consolazio, C. F.; R. E. Johnson; and L. J. Pecora, Physiological Measurements of Metabolic Functions in Man, McGraw-Hill Book Company: New York, 1963, p. 220-228.
2. Pollock, M. L.; Loughridge, E. E.; Coleman, B., Linnerud, A. C.; and Jackson, A, "Prediction of Body Density in Young and Middle-Aged Women," J. Appl. Physiol., 6:74 (1974).
3. Brozek, J.; Grande, F.; Anderson, J. T.; and Keys, A., "Densitometric Analysis of Body Composition: Revision of Some Quantitative Assumptions," N. Y. Acad. Sci., 110:113-40 (1963).
4. Clarke, H. H. and R. A. Munroe, Test Manual. Oregon Cable-Tension Strength Test Batteries for Boys and Girls From Fourth Grade Through College, University of Oregon: Eugene, Oregon, 1970, pp. 13-30, 55061.
5. Personal communication from NASA astronaut Bill Thornton.
6. Balke, B. and Ware, R., "An experimental study of physical fitness of Air Force personnel," U.S. Armed Forces Medical Journal 10:675-88 (1959).